

WHAT IS CLAIMED IS:

1. A positive resist composition comprising:

(A) a fluorine group-containing resin having: a structure wherein at least one of the main chain and the side chain of the polymer skeleton has at least one fluorine atom; and a group capable of decomposing under the action of an acid to increase the solubility in an alkali developer;

(B) a compound capable of generating an acid upon irradiation with at least one of an actinic ray or radiation; and

(C) a surfactant containing at least one of a silicon atom and fluorine atom.

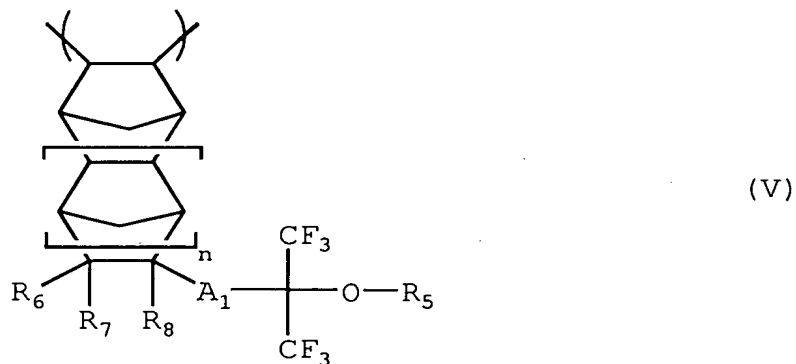
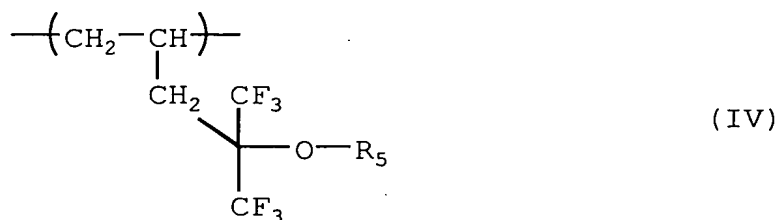
2. The positive resist composition as claimed in claim 1, wherein the resin (A) comprises at least one of fluorine group-containing resins (i) and (ii) below:

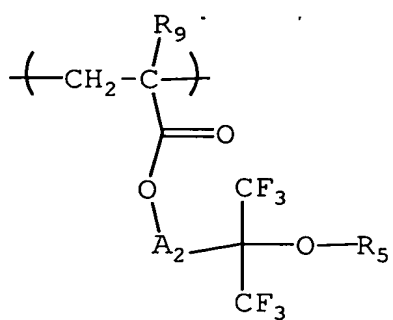
(iii) a fluorine group-containing resin having at least one selected from a perfluoroalkylene group and a perfluoroarylene group as a part or all of the main chain of the polymer skeleton;

(iv) a fluorine group-containing resin having at least one selected from a perfluoroalkyl group, a perfluoroaryl group, a hexafluoro-2-propanol group and a group wherein the OH group in a hexafluoro-2-

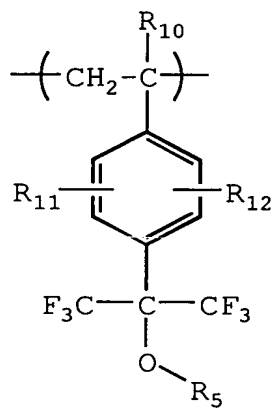
propanol group is protected, as a part or all of the side chain of the polymer skeleton.

3. The positive resist composition as claimed in claim 1, wherein the resin (A) contains at least one of repeating units represented by formulae (I) to (X):

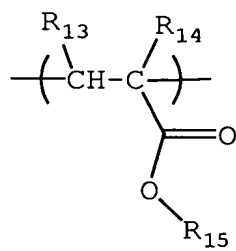




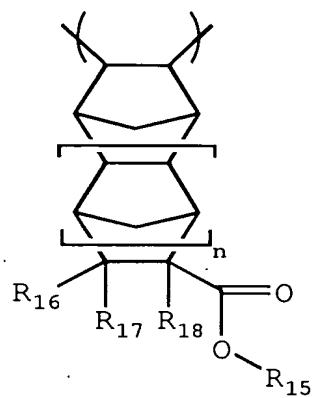
(VI)



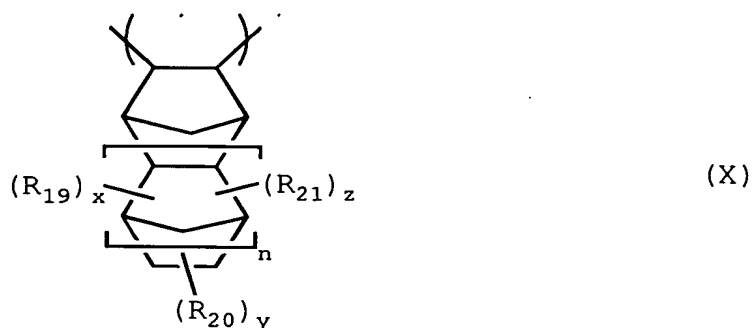
(VII)



(VIII)



(IX)



wherein R_0 and R_1 each represents a hydrogen atom, a fluorine atom, or an alkyl, perfluoroalkyl, cycloalkyl or aryl group, each of which may have a substituent;

R_2 to R_4 each represents an alkyl, perfluoroalkyl, cycloalkyl or aryl group, each of which may have a substituent and R_0 and R_1 may combine to form a ring, R_0 and R_2 may combine to form a ring and R_3 and R_4 may combine to form a ring;

R_5 represents a hydrogen atom, an alkyl, perfluoroalkyl, monocyclic or polycyclic cycloalkyl, acyl or alkoxycarbonyl group, each of which may have a substituent;

R_6 , R_7 and R_8 each represents a hydrogen atom, a halogen atom or an alkyl, perfluoroalkyl or alkoxy group, each of which may have a substituent;

R_9 and R_{10} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent;

R_{11} and R_{12} each represents a hydrogen atom, a hydroxyl group, a halogen atom a cyano group, an alkoxy group, an acyl group, an alkyl, cycloalkyl, alkenyl, aralkyl or aryl

group, and the alkyl, the cycloalkyl, the alkenyl, the aralkyl or the aryl group each may have a substituent;

R_{13} and R_{14} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl, each of which may have a substituent;

R_{15} represents an alkyl, monocyclic or polycyclic cycloalkyl, alkenyl, aralkyl or aryl group, each of which has a fluorine atom;

R_{16} , R_{17} and R_{18} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl, perfluoroalkyl, alkoxy or $-\text{CO}-\text{O}-R_{15}$ group, each of which may have a substituent;

R_{19} , R_{20} and R_{21} each represents a hydrogen atom, a fluorine atom or an alkyl, monocyclic or polycyclic cycloalkyl, alkenyl, aralkyl, aryl or alkoxy group, each of which has a fluorine atom, provided that at least one of R_{19} , R_{20} and R_{21} is a group other than a hydrogen atom;

A_1 and A_2 each represents a single bond, a divalent alkylene, alkenylene, cycloalkylene, arylene group, $-\text{O}-\text{CO}-R_{22}-$, $-\text{CO}-\text{O}-R_{23}-$ or $-\text{CO}-\text{N}(R_{24})-R_{25}-$, and the divalent alkylene, alkenylene, cycloalkylene or arylene group each may have a substituent;

R_{22} , R_{23} and R_{25} each represents a single bond or a divalent alkylene, alkenylene, cycloalkylene or arylene group, each of which may have an ether group, an ester

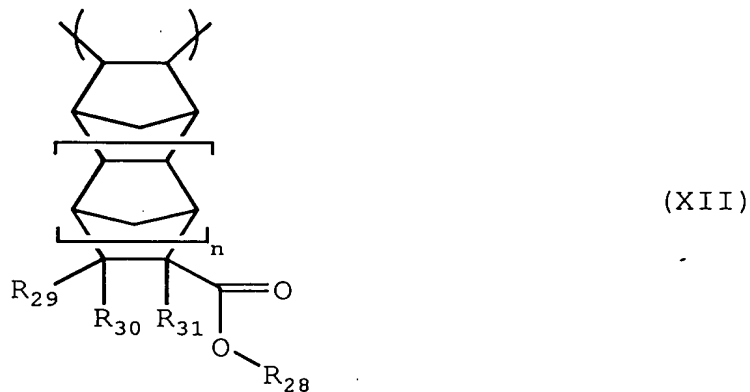
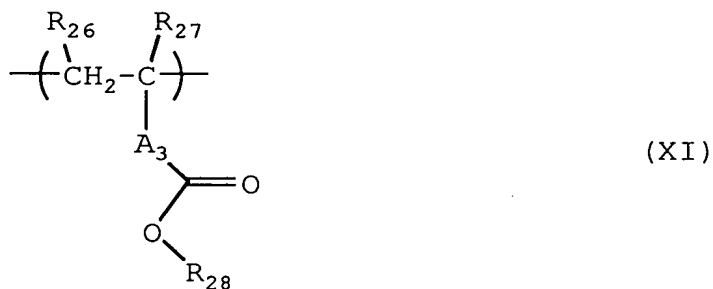
group, an amide group, a urethane group or a ureido group;

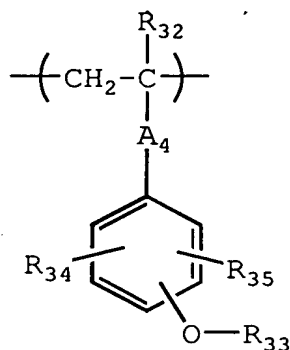
R_{24} represents a hydrogen atom or an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent;

n represents 0 or 1; and

x , y and z each represents an integer of 0 to 4.

4. The positive resist composition as claimed in claim 1, wherein the resin (A) contains at least one of repeating units represented by formulae (XI) to (XIII):

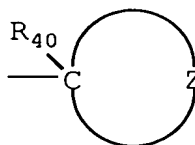




(XIII)

wherein R_{26} , R_{27} and R_{32} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent;

R_{28} and R_{33} each represents $\text{---C}(\text{R}_{36})(\text{R}_{37})(\text{R}_{38})$, $\text{---C}(\text{R}_{36})(\text{R}_{37})(\text{OR}_{39})$ or a group represented by formula (XIV):



(XIV)

wherein R_{29} , R_{30} and R_{31} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl, perfluoroalkyl, alkoxy or $\text{---CO---O---R}_{28}$ group, each of which may have a substituent;

R_{34} and R_{35} each represents a hydrogen atom, a hydroxyl group, a halogen atom, a cyano group, an alkoxy group, an acyl group, an alkyl, cycloalkylene, alkenyl, aralkyl or aryl group, and the alkyl, cycloalkylene, alkenyl, aralkyl or aryl group each may have a substituent;

R_{36} , R_{37} , R_{38} and R_{39} each represents an alkyl,

cycloalkyl, alkenyl, aralkyl or aryl group, each of which may have a substituent, and two of R_{36} , R_{37} and R_{38} , or two of R_{36} , R_{37} and R_{39} may combine to form a ring;

R_{40} represents an alkyl, cycloalkyl, alkenyl, alkynyl, aralkyl or aryl group, each of which may have a substituent;

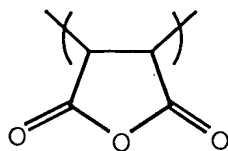
A_3 and A_4 each represents a single bond, a divalent alkylene, alkenylene, cycloalkylene, arylene group, $-O-CO-R_{22}-$, $-CO-O-R_{23}-$ or $-CO-N(R_{24})-R_{25}-$, and the divalent alkylene, alkenylene, cycloalkylene or arylene group, each of which may have a substituent;

R_{22} to R_{25} have the same meanings as above;

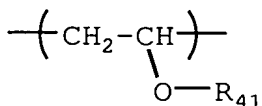
Z represents an atomic group constituting a monocyclic or polycyclic alicyclic group together with the carbon atom; and

n represents 0 or 1.

5. The positive composition as claimed in claim 1, wherein the resin (A) contains at least one of repeating units represented by formulae (XV) to (XVII):



(XV).



(XVI)



wherein R_{41} represents an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent;

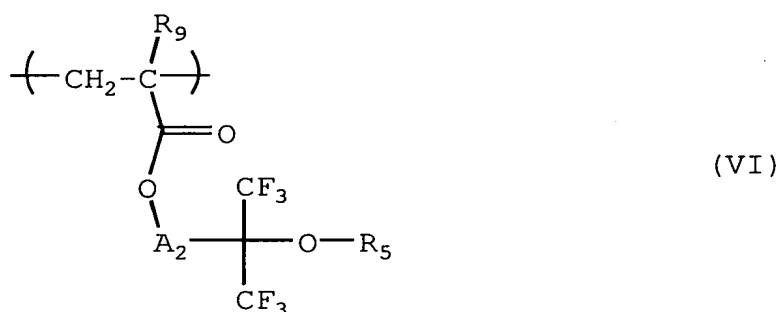
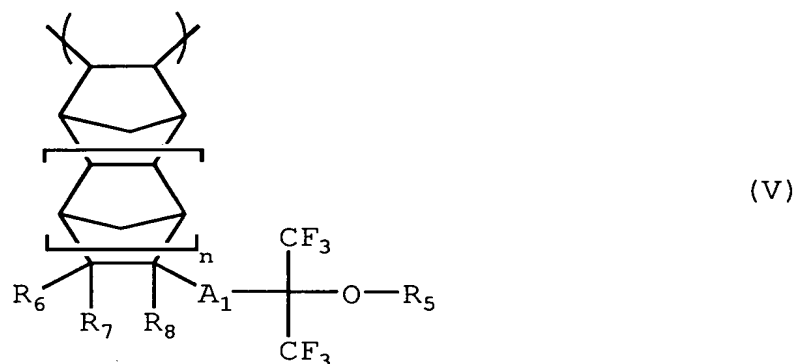
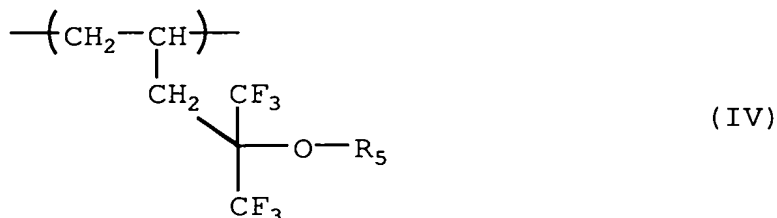
R_{42} represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent;

A_5 represents a single bond, a divalent alkylenes, alkenylene, cycloalkylene, arylene group, $-\text{O}-\text{CO}-\text{R}_{22}-$, $-\text{CO}-\text{O}-\text{R}_{23}-$ or $-\text{CO}-\text{N}(\text{R}_{24})-\text{R}_{25}-$, and the divalent alkylenes, alkenylene, cycloalkylene or arylene group each may have a substituent;

R_{22} to R_{25} have the same meanings as above.

6. The positive resist composition as claimed in claim 1, wherein the resin (A) contains: at least one of repeating units represented by formulae (I) to (III); and at least one of repeating units represented by formulae (IV) to (VI):





wherein R₀ and R₁ each represents a hydrogen atom, a fluorine atom or an alkyl, perfluoroalkyl, cycloalkyl or aryl group, each of which may have a substituent,

R₂ to R₄ each represents an alkyl, perfluoroalkyl, cycloalkyl or aryl group, each of which may have a substituent, and R₀ and R₁ may combine to form a ring, R₀ and R₂ may combine to form a ring, and R₃ and R₄ may combine

to form a ring;

R_5 represents a hydrogen atom or an alkyl, perfluoroalkyl, monocyclic or polycyclic cycloalkyl, acyl or alkoxy carbonyl group, each of which may have a substituent;

R_6 , R_7 and R_8 each represents a hydrogen atom, a halogen atom or an alkyl, perfluoroalkyl or alkoxy group, each of which may have a substituent;

R_9 represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent;

A_1 and A_2 each represents a single bond, a divalent alkylene, alkenylene, cycloalkylene, arylene group, $-O-CO-R_{22}-$, $-CO-O-R_{23}-$ or $-CO-N(R_{24})-R_{25}-$, and the divalent alkylene, alkenylene, cycloalkylene or arylene group each may have a substituent;

R_{22} , R_{23} and R_{25} each represents a single bond or a divalent alkylene, alkenylene, cycloalkylene or arylene group, each of which may have an ether group, an ester group, an amide group, a urethane or a ureido group;

R_{24} represents a hydrogen atom or an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent; and

n represents 0 or 1.

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Chemical structure of a copolymer repeat unit. The structure is enclosed in brackets with a subscript n . It features a central bicyclic core (a cyclobutane ring fused to two cyclohexane rings) with four substituents: $(R_{19})_x$, $(R_{20})_y$, and $(R_{21})_z$.

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group, or an alkyl or haloalkyl group, each of which may have a substituent;

R_{13} and R_{14} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent;

R_{15} represents an alkyl, monocyclic or polycyclic cycloalkyl, alkenyl, aralkyl or aryl group, each of which has a fluorine atom;

R_{16} , R_{17} and R_{18} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl, perfluoroalkyl, alkoxy or $-\text{CO}-\text{O}-R_{15}$ group, each of which may have a substituent;

R_{19} , R_{20} and R_{21} each represents a hydrogen atom, a fluorine atom or an alkyl, monocyclic or polycyclic cycloalkyl, alkenyl, aralkyl, aryl or alkoxy group, each of which has a fluorine atom, provided that at least one of R_{19} , R_{20} and R_{21} is a group other than a hydrogen atom;

A_1 and A_2 each represents a single bond, a divalent alkylene, alkenylene, cycloalkylene, arylene group, $-\text{O}-\text{CO}-R_{22}-$, $-\text{CO}-\text{O}-R_{23}-$ or $-\text{CO}-\text{N}(R_{24})-R_{25}-$, and the divalent alkylene, alkenylene, cycloalkylene or arylene group each may have a substituent;

R_{22} , R_{23} and R_{25} each represents a single bond or a divalent alkylene, alkenylene, cycloalkylene or arylene group, each of which may have an ether group, an ester

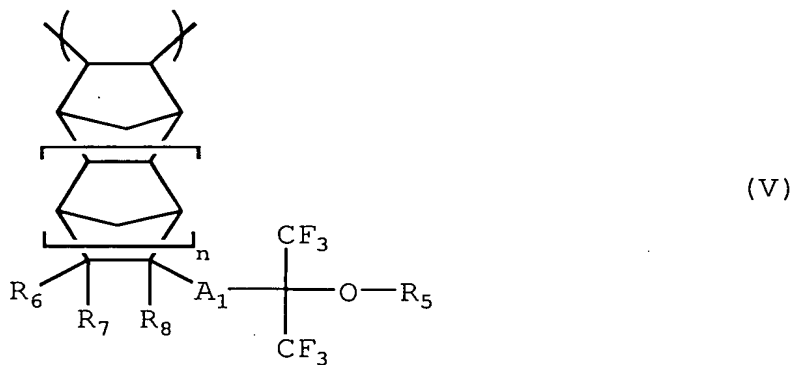
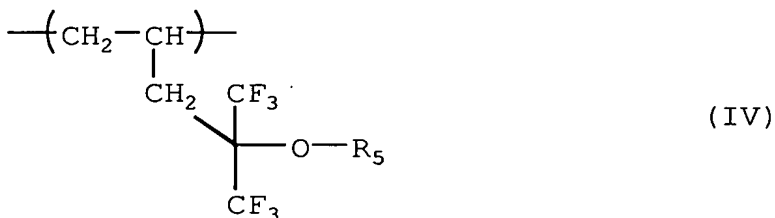
group, an amide group, a urethane group or a ureido group;

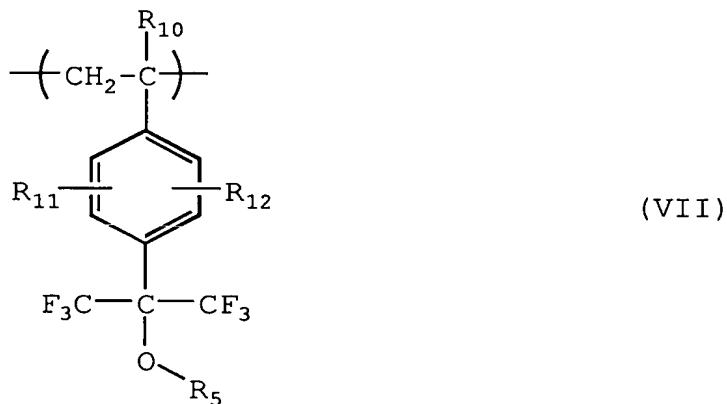
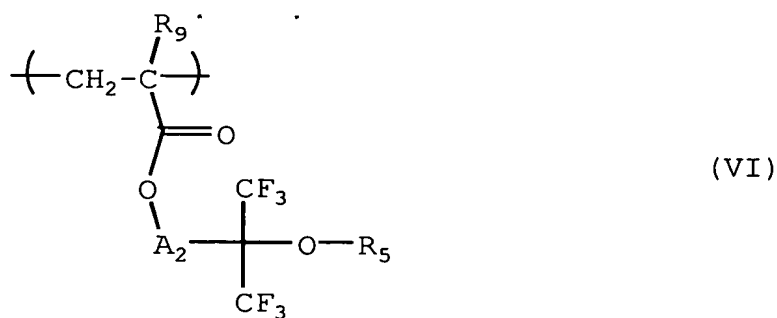
R_{24} represents a hydrogen atom or an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent;

n represents 0 or 1; and

x , y and z each represents an integer of 0 to 4.

8. The positive resist composition as claimed in claim 1, wherein the resin (A) contains: at least one of repeating units represented by formulae (IV) to (VII) below; and at least one of repeating units represented by formulae (XV) to (XVII) below:





wherein R_5 represents a hydrogen atom or an alkyl, perfluoroalkyl, monocyclic or polycyclic cycloalkyl, acyl or alkoxy carbonyl group, each of which may have a substituent;

R_6 , R_7 and R_8 each represents a hydrogen atom, a

halogen atom, or an alkyl, perfluoroalkyl or alkoxy group, each of which may have a substituent;

R_9 and R_{10} each represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent;

R_{11} and R_{12} each represents a hydrogen atom, a hydroxyl group, a halogen atom, a cyano group, an alkoxy group, an acyl group, an alkyl, cycloalkyl, alkenyl, aralkyl or aryl group, and the alkyl, cycloalkyl, alkenyl, aralkyl or aryl group each may have a substituent;

A_1 and A_2 each represents a single bond or a divalent alkylene, alkenylene, cycloalkylene, arylene group, $-O-CO-R_{22}-$, $-CO-O-R_{23}-$ or $-CO-N(R_{24})-R_{25}-$, and the divalent alkylene, alkenylene, cycloalkylene or arylene group each may have a substituent;

R_{22} , R_{23} and R_{25} each represents a single bond or a divalent alkylene, alkenylene, cycloalkylene or arylene group, each of which may have an ether group, an ester group, an amide group, a urethane group or a ureido group;

R_{24} represents a hydrogen atom or an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent;

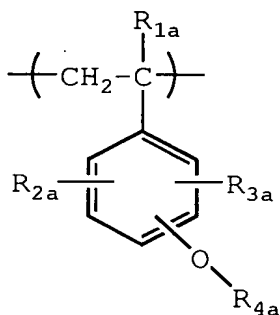
n represents 0 or 1;

R_{41} represents an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent;

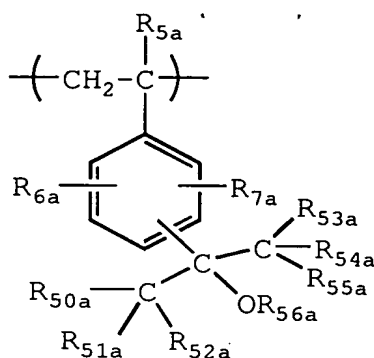
R_{42} represents a hydrogen atom, a halogen atom, a cyano group, or an alkyl or haloalkyl group, each of which may have a substituent; and

A_5 represents a single bond, a divalent alkylene, alkenylene, cycloalkylene, arylene group, $-O-CO-R_{22}-$, $-CO-O-R_{23}-$ or $-CO-N(R_{24})-R_{25}-$, and the divalent alkylene, alkenylene, cycloalkylene or arylene group each may have a substituent.

9. The positive resist composition as claimed in claim 1, wherein the resin (A) contains: at least one of repeating units represented by formula (IA) below; and at least one of repeating units represented by formula (IIA) below:



(IA)



(IIA)

wherein R_{1a} and R_{5a} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl group which may have a substituent;

R_{2a} , R_{3a} , R_{6a} and R_{7a} each represents a hydrogen atom, a halogen atom, a cyano group, a hydroxyl group or an alkyl, cycloalkyl, alkoxy, acyl, acyloxy, alkenyl, aryl or aralkyl group, each of which may have a substituent;

R_{50a} to R_{55a} each represents a hydrogen atom, a fluorine atom or an alkyl group which may have a substituent, and at least one of R_{50a} to R_{55a} represents a fluorine atom or an alkyl group where at least one hydrogen atom is substituted by a fluorine atom;

R_{56a} represents a hydrogen atom or an alkyl, cycloalkyl, acyl or alkoxycarbonyl group, each of which may have a substituent;

R_{4a} represents a group represented by formula (IVA) or (VA):



wherein in formula (IVA), R_{11a} , R_{12a} and R_{13a} each represents an alkyl, cycloalkyl, alkenyl, aralkyl or aryl group, each of which may have a substituent; and

in formula (VA), R_{14a} and R_{15a} each represents a hydrogen atom or an alkyl group which may have a substituent; and

R_{16a} represents an alkyl, cycloalkyl, aralkyl or aryl group, each of which may have a substituent, and two of R_{14a} to R_{16a} may combine to form a ring.

10. The positive resist composition as claimed in claim 1, wherein the resin (A) contains: at least one of repeating units represented by formula (IIA) below; and at least one of repeating units represented by (VIA) below:

in formula (VIA), R_{17a1} and R_{17a2} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl group which may have a substituent;

R_{18a} represents $-C(R_{18a1})(R_{18a2})(R_{18a3})$ or $-C(R_{18a1})(R_{18a2})(OR_{18a4})$;

R_{18a1} to R_{18a4} each represents a hydrogen atom or an alkyl, cycloalkyl, alkenyl, aralkyl or aryl group, each of which may have a substituent, and two of R_{18a1} , R_{18a2} and R_{18a3} or two of R_{18a1} , R_{18a2} and R_{18a4} may combine to form a ring; and

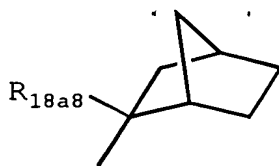
A_0 represents a single bond or a divalent linking group which may have a substituent.

11. The positive resist composition as claimed in claim 10, wherein in formula (VIA), R_{18a} is a group represented by formula (VIA-A):



wherein R_{18a5} and R_{18a6} each represents an alkyl group which may have a substituent; and R_{18a7} represents a cycloalkyl group which may have a substituent.

12. The positive resist composition as claimed in claim 10, wherein in formula (VIA), R_{18a} is a group represented by formula (VIA-B):



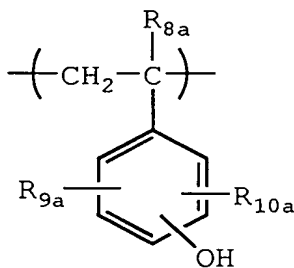
(VIA-B)

wherein R_{18a8} represents an alkyl, alkenyl, alkynyl, aralkyl or aryl group, each of which may have a substituent.

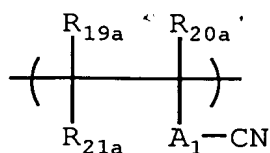
13. The positive resist composition as claimed in claim 9, wherein at least one of R_{1a} in formula (IA) and R_{5a} in formula (IIA) is a trifluoromethyl group.

14. The positive resist composition as claimed in claim 10, wherein at least one of R_{5a} in formula (IIA) and R_{17a2} in formula (VIA) is a trifluoromethyl group.

15. The positive resist composition as claimed in claims 9, wherein the resin (A) further contains at least one of repeating units represented by formulae (IIIA) and (VIIA):



(IIIA)

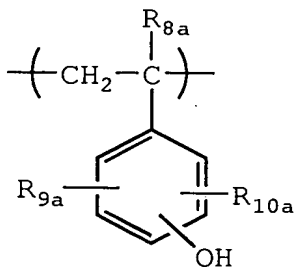


(VIIA)

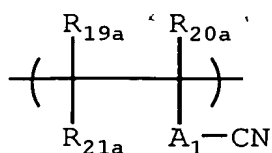
wherein in formula (IIIA), R_{8a} represents a hydrogen atom, a halogen atom, a cyano group or an alkyl group which may have a substituent; R_{9a} and R_{10a} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl, cycloalkyl, alkoxy, acyl, acyloxy, alkenyl, aryl or aralkyl group, each of which may have a substituent; and

in formula (VIIA), R_{19a} and R_{20a} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl group which may have a substituent, R_{21a} represents a hydrogen atom, a halogen atom, an alkyl which may have a substituent or $\text{---A}_1\text{---CN}$ group; and A_1 represents a single bond or a divalent linking group.

16. The positive resist composition as claimed in claim 10, wherein the resin (A) further contains at least one of repeating units represented by formulae (IIIA) and (VIIA):



(IIIA)



(VIIA)

wherein in formula (IIIA), R_{8a} represents a hydrogen atom, a halogen atom, a cyano group or an alkyl group which may have a substituent; R_{9a} and R_{10a} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl, cycloalkyl, alkoxy, acyl, acyloxy, alkenyl, aryl or aralkyl group, each of which may have a substituent; and

in formula (VIIA), R_{19a} and R_{20a} each represents a hydrogen atom, a halogen atom, a cyano group or an alkyl group which may have a substituent, R_{21a} represents a hydrogen atom, a halogen atom, an alkyl which may have a substituent or $-A_1-CN$ group; and A_1 represents a single bond or a divalent linking group.

17. The positive resist composition as claimed in claim 1, which further comprises a compound containing a basic nitrogen atom.

18. The positive resist composition as claimed in claim 1, wherein the compound (B) comprises at least one compound selected from sulfonium salt and iodonium salt compounds capable of generating at least one of acids (i) to (iii) below upon irradiation with one of an actinic ray and radiation:

- (i) a perfluoroalkylsulfonic acid having 2 or more carbon atoms;
- (ii) a perfluoroarylsulfonic acid; and
- (iii) an arylsulfonic acid having a perfluoroalkyl group as a substituent.

19. The positive resist composition as claimed in claim 1, which is a composition to be irradiated with an ultraviolet ray having a wave length of 160 nm or less.

20. The positive resist composition as claimed in claim 19, wherein the ultraviolet ray is F₂ excimer laser ray having a wave length of 157 nm.